AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Currently amended) A method for <u>improving computation efficiency in solving</u> ~~using a computer system to solve~~ a global optimization problem specified by a function *f* and a set of equality constraints, the method comprising:

receiving a representation of the function *f* and the set of equality constraints $q_i(\mathbf{x}) = 0$ (i=1,...,r) at the computer system, wherein *f* is a scalar function of a vector $\mathbf{x} = (x_1, x_2, x_3, \ldots x_n)$;

storing the representation in a memory within the computer system;

performing an interval global optimization process to compute guaranteed bounds on a globally minimum value of the function $f(\mathbf{x})$ subject to the set of equality constraints <u>with improved computation efficiency</u>;

<u>wherein performing computations during interval global optimization process involves using a special-purpose interval arithmetic unit for interval computations;</u>

wherein performing the interval global optimization process involves,

applying term consistency to the set of equality constraints over a subbox **X**, and

excluding portions of the subbox **X** that can be shown to violate any of the equality constraints;

<u>wherein applying term consistency involves:</u>

<u>symbolically manipulating an equation within the computer system to solve for a term, $g(x_j)$, thereby producing a modified</u>

equation $g(x_j) = h(\mathbf{x})$, wherein the term $g(x_j)$ can be analytically inverted to produce an inverse function $g^{-1}(y)$;

substituting the subbox $\mathbf{X}$ into the modified equation to produce the equation $g(X'_j) = h(\mathbf{X})$;

solving for $X'_j = g^{-1}(h(\mathbf{X}))$; and

intersecting X'_j with the interval X_j to produce a new subbox $\mathbf{X}^+$;

wherein the new subbox $\mathbf{X}^+$ contains all solutions of the equation within the subbox $\mathbf{X}$, and wherein the size of the new subbox $\mathbf{X}^+$ is less than or equal to the size of the subbox $\mathbf{X}$.

2. (Original) The method of claim 1, wherein performing the interval global optimization process involves:

preconditioning the set of equality constraints through multiplication by an approximate inverse matrix **B** to produce a set of preconditioned equality constraints;

applying term consistency to the set of preconditioned equality constraints over the subbox **X**; and

excluding portions of the subbox **X** that can be shown to violate any of the preconditioned equality constraints.

3. (Original) The method of claim 1, wherein performing the interval global optimization process involves:

keeping track of a least upper bound *f_bar* of the function $f(\mathbf{x})$;

unconditionally removing from consideration any subbox for which $inf(f(\mathbf{x})) > f\_bar$;

applying term consistency to the inequality $f(\mathbf{x})$ # *f_bar* over the subbox **X**; and

excluding portions of the subbox **X** that violate the inequality.

4. (Canceled)

5. (Original) The method of claim 1, wherein performing the interval global optimization process involves:

applying box consistency to the set of equality constraints $q_i(\mathbf{x}) = 0$ $(i=1,\ldots,r)$ over the subbox **X**; and

excluding portions of the subbox **X** that violate the set of equality constraints.

6. (Original) The method of claim 1, wherein performing the interval global o+ptimization process involves:

evaluating a first termination condition;

wherein the first termination condition is TRUE if a function of the width of the subbox **X** is less than a pre-specified value, ε_X, and the absolute value of the function, f, over the subbox **X** is less than a pre-specified value, ε_F; and

if the first termination condition is TRUE, terminating further splitting of the subbox **X**.

7. (Original) The method of claim 1, wherein performing the interval global optimization process involves performing an interval Newton step on the John conditions.

8. (Currently amended) A computer-readable storage medium storing instructions that when executed by a computer system cause the computer system to perform a method for <u>improving computation efficiency in solving</u>~~using a~~

~~computer system to solve~~ a global optimization problem specified by a function f and a set of equality constraints, the method comprising:

receiving a representation of the function f and the set of equality constraints $q_i(\mathbf{x}) = 0$ ($i=1,\ldots,r$) at the computer system, wherein f is a scalar function of a vector $\mathbf{x} = (x_1, x_2, x_3, \ldots x_n)$;

storing the representation in a memory within the computer system;

performing an interval global optimization process to compute guaranteed bounds on a globally minimum value of the function $f(\mathbf{x})$ subject to the set of equality constraints with improved computation efficiency;

wherein performing computations during interval global optimization process involves using a special-purpose interval arithmetic unit for interval computations;

wherein performing the interval global optimization process involves,

applying term consistency to the set of equality constraints over a subbox $\mathbf{X}$, and

excluding portions of the subbox $\mathbf{X}$ that can be shown to violate any of the equality constraints;

wherein applying term consistency involves:

symbolically manipulating an equation within the computer system to solve for a term, $g(x_j)$, thereby producing a modified equation $g(x_j) = h(\mathbf{x})$, wherein the term $g(x_j)$ can be analytically inverted to produce an inverse function $g^{-1}(y)$;

substituting the subbox $\mathbf{X}$ into the modified equation to produce the equation $g(X'_j) = h(\mathbf{X})$;

solving for $X'_j = g^{-1}(h(\mathbf{X}))$; and

intersecting X'_j with the interval X_j to produce a new subbox $\mathbf{X}^+$;

wherein the new subbox $\mathbf{X}^+$ contains all solutions of the equation within the subbox **X**, and wherein the size of the new subbox $\mathbf{X}^+$ is less than or equal to the size of the subbox **X**.

9. (Original) The computer-readable storage medium of claim 8, wherein performing the interval global optimization process involves:

preconditioning the set of equality constraints through multiplication by an approximate inverse matrix **B** to produce a set of preconditioned equality constraints;

applying term consistency to the set of preconditioned equality constraints over the subbox **X**; and

excluding portions of the subbox **X** that can be shown to violate any of the preconditioned equality constraints.

10. (Original) The computer-readable storage medium of claim 8, wherein performing the interval global optimization process involves:

keeping track of a least upper bound *f_bar* of the function *f*(**x**);

unconditionally removing from consideration any subbox for which *inf*(*f*(**x**)) > *f_bar*;

applying term consistency to the inequality *f*(**x**) # *f_bar* over the subbox **X**; and

excluding portions of the subbox **X** that violate the inequality.

11. (Canceled)

12. (Original) The computer-readable storage medium of claim 8, wherein performing the interval global optimization process involves:

applying box consistency to the set of equality constraints $q_i(\mathbf{x}) = 0$ $(i=1,...,r)$ over the subbox **X**; and

excluding portions of the subbox **X** that violate the set of equality constraints.

13. (Original) The computer-readable storage medium of claim 8, wherein performing the interval global optimization process involves:

evaluating a first termination condition;

wherein the first termination condition is TRUE if a function of the width of the subbox **X** is less than a pre-specified value, ε_X, and the absolute value of the function, f, over the subbox **X** is less than a pre-specified value, ε_F; and

if the first termination condition is TRUE, terminating further splitting of the subbox **X**.

14. (Original) The computer-readable storage medium of claim 8, wherein performing the interval global optimization process involves performing an interval Newton step on the John conditions.

15. (Currently amended) An apparatus that improves computation efficiency in solving ~~solves~~ a global optimization problem specified by a function f and a set of equality constraints, the apparatus comprising:

a receiving mechanism that is configured to receive a representation of the function f and the set of equality constraints $q_i(\mathbf{x}) = 0$ $(i=1,...,r)$, wherein f is a scalar function of a vector $\mathbf{x} = (x_1, x_2, x_3, \ldots x_n)$;

a memory for storing the representation;

an optimizer that is configured to perform an interval global optimization process to compute guaranteed bounds on a globally minimum value of the

function $f(\mathbf{x})$ subject to the set of equality constraints with improved computation efficiency;

wherein the optimizer configured to perform computations during interval global optimization process involves using a special-purpose interval arithmetic unit for interval computations;

wherein the optimizer is configured to,

apply term consistency to the set of equality constraints over a subbox $\mathbf{X}$, and to

exclude portions of the subbox $\mathbf{X}$ that can be shown to violate any of the equality constraints;

wherein while applying term consistency, the optimizer is configured to:

symbolically manipulate an equation to solve for a term, $g(x_j)$, thereby producing a modified equation $g(x_j) = h(\mathbf{x})$, wherein the term $g(x_j)$ can be analytically inverted to produce an inverse function $g^{-1}(y)$;

substitute the subbox $\mathbf{X}$ into the modified equation to produce the equation $g(X'_j) = h(\mathbf{X})$;

solve for $X'_j = g^{-1}(h(\mathbf{X}))$; and to

intersect X'_j with the interval X_j to produce a new subbox $\mathbf{X}^+$;

wherein the new subbox $\mathbf{X}^+$ contains all solutions of the equation within the subbox $\mathbf{X}$, and wherein the size of the new subbox $\mathbf{X}^+$ is less than or equal to the size of the subbox $\mathbf{X}$.

16. (Original) The apparatus of claim 15, wherein the optimizer is configured to:

precondition the set of equality constraints through multiplication by an approximate inverse matrix **B** to produce a set of preconditioned equality constraints;

apply term consistency to the set of preconditioned equality constraints over the subbox **X**; and to

exclude portions of the subbox **X** that can be shown to violate any of the preconditioned equality constraints.

17. (Original) The apparatus of claim 15, wherein the optimizer is configured to:

keep track of a least upper bound *f_bar* of the function *f*(**x**);

unconditionally remove from consideration any subbox for which *inf*(*f*(**x**)) > *f_bar*;

apply term consistency to the inequality *f*(**x**) # *f_bar* over the subbox **X**; and to

exclude portions of the subbox **X** that violate the inequality.

18. (Canceled)

19. (Original) The apparatus of claim 15, wherein the optimizer is configured to:

apply box consistency to the set of equality constraints $q_i(\mathbf{x}) = 0$ (i=1,...,r) over the subbox **X**; and to

exclude portions of the subbox **X** that violate the set of equality constraints.

20. (Original) The apparatus of claim 15, wherein the optimizer is configured to:

evaluate a first termination condition;

wherein the first termination condition is TRUE if a function of the width of the subbox **X** is less than a pre-specified value, ε_X, and the absolute value of the function, *f*, over the subbox **X** is less than a pre-specified value, ε_F; and to

terminate further splitting of the subbox **X** if the first termination condition is TRUE

21. (Original) The apparatus of claim 15, wherein the optimizer is configured to perform an interval Newton step on the John conditions.